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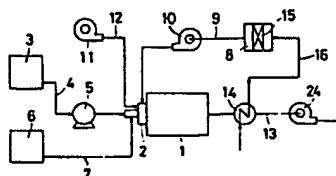
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54 Liquid fuel combustion apparatus.

57 A combustion apparatus for burning liquid fuels, having  
 a burner 2 for atomizing and burning the liquid fuels. The  
 combustion apparatus comprises supply means for sup-  
 plying oxygen-enriched air obtained by passing normal air  
 through an oxygen permselective membrane 15 to the  
 burner 2 as air for combustion.

Fig. 1



DESCRIPTION

LIQUID FUEL COMBUSTION APPARATUS

The present invention relates to an apparatus for combustion of liquid fuels.

It has heretofore been difficult to effectuate a satisfactory combustion of liquid fuels having a high degree of viscosity and, in addition, containing a large amount of organic nitrogen compounds, for example, heavy oil.

The object of the present invention is to provide an apparatus for burning liquid fuels such as heavy oil with satisfactory results, bringing about a solution to such technical problem as mentioned above.

To accomplish the foregoing object, there is provided a liquid fuel combustion apparatus, having a burner for atomizing and burning the liquid fuels, which comprises supply means for supplying oxygen-enriched air obtained by passing normal air through an oxygen permselective membrane to the burner as air for combustion.

According to the present invention, liquid fuel is atomized by gaseous fuel and, besides, oxygen-enriched air is utilized, it is possible to achieve a satisfactory combustion of liquid fuels such as heavy oil, with the generation of NO<sub>x</sub> restrained.

According to the preferred embodiment of the invention, liquid fuels are atomized with gaseous fuels or nitrogen-enriched air. In addition, oxygen-enriched air or air for supplying an oxygen permselective membrane is pre-heated with exhaust gas by heat exchange. Furthermore, the oxygen-enriched air is obtained from the normal air, and supplied to the burner as primary air.

According to this example, it has been so devised that liquid fuel is atomized by means of nitrogen-enriched air, while oxygen-enriched air is supplied as the secondary air; therefore it is possible to achieve a satisfactory combustion, with a reduction in the amount of NO<sub>x</sub> generated.

In accordance with the invention, there are provided first channel, second channel and third channel concentrically disposed in the order from inside outward in the radial direction. The first channel is for use to be supplied with liquid fuels, the second channel is for use to be supplied with oxygen-enriched air formed by means of oxygen-enriched air generating means, and the third channel is for use to be supplied with normal air.

According to the embodiment, it is so devised that liquid fuel is atomized by an air of which the concentration of oxygen has been made higher by utilization of an oxygen enriching means; therefore an improvement is brought about in the combustion temperature of liquid fuels.

A detailed description of the invention will be made with reference to the accompanying drawings wherein like numerals designate corresponding parts in the figures.

Fig. 1 is the diagram of an example of the embodiment of the present invention;

Fig. 2 is an enlarged cross-sectional view of the burner in Fig. 1, showing its structure;

Fig. 3 is the diagram of another example of the embodiment of this invention;

Fig. 4 is an enlarged cross-sectional view of the burner in Fig. 3, showing its structure; and

Fig. 5 is an enlarged cross-sectional view of the burner in still another embodiment of the invention.

Fig. 1 is the diagram of an example of the embodiment of the present invention. A combustion furnace 1 is provided with a burner 2. This burner 2 is supplied with a liquid fuel, for example, heavy oil, stored in a tank 3, by means of a pump 5 provided midway in a pipe conduit 4. It is also supplied with a gaseous fuel, for example town gas or liquefied natural gas, from a tank 6, through a pipe conduit 7. Further, oxygen-enriched air obtained by an oxygen-enriched air generating means 8 is supplied, as the primary air, to the burner 2 by means of an induction fan 10 provided midway in a pipe conduit 9. Still further, air drawn in from the atmosphere by a force blower 11 is supplied through a pipe conduit 12 to the

burner 2, as the secondary air.

In the burner 2, liquid fuel is atomized by gaseous fuel and is burned with the primary and secondary airs. In virtue of such, an efficient combustion, with a reduction in the amount of NO<sub>x</sub> generated, is realized. Waste gas from the combustion in the burner 2 is exhausted from an outlet of the combustion furnace 1 through an exhaust gas duct 13, induced into it by an induction fan 24 provided at its end. Midway in the exhaust gas duct 13, there is provided a heat exchanger 14 for the purpose of heat exchange between combustion waste gas and air.

The oxygen-enriched air generating means 8 is provided with an oxygen permselective membrane 15 which is made of an ultrathin film of high molecular silicon compound; and this oxygen permselective membrane 15 performs the function of increasing the concentration of oxygen in the air flowing through it to about 23 to 31 %. Furthermore, said oxygen permselective membrane 15 is possessed of such a property that the higher the temperature of air flowing through it, the larger becomes the amount of oxygen-enriched air obtained. For instance, when the air temperature is raised from 20°C to 80°C, it is possible to obtain about twice as much oxygen-enriched air with the same concentration of oxygen. Into such oxygen-enriched air generating means 8 as described above, air preheated by the heat exchanger 14

is introduced through a pipe conduit 16. Accordingly, it is possible to obtain a relatively large amount of oxygen-enriched air; and this oxygen-enriched air is introduced into the burner 2 through the pipe conduit 9, by means of the induction fan 10.

Fig. 2 is an enlarged cross-sectional view of the burner 2, showing its structure. At a part of the main body of furnace 1a of the combustion furnace 1, there is formed an opening 17; and at this opening 17, there is installed the burner 2, facing the inside of the combustion furnace 1. The burner 2 comprises an external casing 18 in cylindrical form, with a bottom covering the opening 17, an internal casing 19 in cylindrical form, which is concentrically thrust into the external casing 18 and which has a bottom with an opening toward the opening 17 of the main body of furnace 1a, and a fuel spraying cylinder 20 which is concentrically thrust into the internal casing 19. Between the exterior surface of the fuel spraying cylinder 20 and the interior surface of the internal casing 19, there is formed the primary air channel 21 in annular form; and midway in this primary air channel 21, there is provided a fixed vane 22 on the exterior surface of the fuel spraying cylinder 20. Further, between the exterior surface of the internal casing 19 and the interior surface of the external casing 18, there is formed the secondary air channel 23 in annular form. The fuel spraying cylinder 20 is a two-

fluid sprayer; and it can be either of the so-called "inside mixing type" or of the "outside mixing type".

To the fuel spraying cylinder 20 are connected a pipe conduit 4 for supply of liquid fuel and a pipe conduit 7 for supply of gaseous fuel. Further, to the internal casing 19 is connected a pipe conduit 9 for supply of oxygen-enriched air to the primary air channel 21; and to the external casing 18 is connected a pipe conduit 12 for supply of air which is not oxygen-enriched to the secondary air channel 23.

Into the burner 2 as described above, liquid fuel is jetted by the fuel spraying cylinder 20, as it is atomized by gaseous fuel. The mixture of atomized liquid fuel and gaseous fuel burns firstly with the primary air which is enriched with oxygen. For this reason, the combustion goes on in an atmosphere having a relatively high concentration of oxygen in its initial stage, hence the efficiency of combustion is improved. Accordingly, high-temperature flames are formed and, in proportion, the luminous flame radiation increases, thus bringing about an improvement in the thermal efficiency of the combustion furnace 1.

There is, on the other hand, a possibility of the formation of high-temperature flames giving rise to an increase of the amount of NO<sub>x</sub> generated. However, as the result of experiments carried out by the inventor, it was found out that, where the liquid fuel used is heavy oil, when

the amount of gaseous fuel supplied is set at 10 to 40 %, in terms of calories, of the total amount of combustibles, a reduction in the amount of NO<sub>x</sub> generated can be realized. When, moreover, the amount of gaseous fuel supplied is set as above, there is brought about an improvement in the brightness of flames and the thermal efficiency is further enhanced.

As for the combustion furnace 1, with an improvement in the burning condition of fuel by virtue of the burner 2, the combustion chamber load is increased; therefore, its size, as a whole, can be made smaller. Where, moreover, the combustion furnace 1 is equipped with an apparatus for desulfurization and/or denitration, the reduction in the amount of combustion gas exhausted, in virtue of oxygen-enriched air used in the burner 2, serves to alleviate the load on such an equipment.

It is to be noted that, as another example of the embodiment of this invention, there can be an omission of the heat exchanger 14, and that oxygen-enriched air may be used both for the primary air and the secondary air.

It is to be further noted that the structure of the burner 2 is not limited to that which is shown in Fig. 2.

Fig. 3 is the diagram of another example of the embodiment of this invention.

In this example, whilst air enriched with oxygen by the oxygen-enriched air generating means 8 is supplied, by



means of the induction fan 10 provided midway in the pipe conduit 9, to the burner 2, an air with a relatively low concentration of oxygen, in other words, nitrogen-enriched air, from the oxygen-enriched air generating means 8, is supplied to the burner 2 through a pipe conduit 25, by means of an induction fan 27 provided midway in it.

In the burner 2, liquid fuel is atomized by the nitrogen-enriched air, as the primary air, and oxygen-enriched air is supplied to it as the secondary air. Accordingly, an efficient combustion, with a reduction in the amount of NO<sub>x</sub> generated, is realized. Waste gas from the combustion in the burner 2 is exhausted from an outlet of the combustion furnace 1 through the exhaust gas duct 13, induced into it by the induction fan 24 provided at its end, into the atmosphere. In addition, midway in the exhaust gas duct 13, there is provided the heat exchanger 14 for the purpose of heat exchange between the oxygen-enriched air downstream the induction fan 10 in the pipe conduit 9 and combustion waste gas. Accordingly, oxygen-enriched air is supplied to the burner 2 after having been preheated.

In the oxygen-enriched air generating means 8, the concentration of oxygen in the air remaining in the upstream of the oxygen permselective membrane 15 becomes relatively low in proportion to the efficiency of oxygen enriching function of the oxygen permselective membrane 15. For the

purpose of supplying this nitrogen-enriched air to the burner 2, the pipe conduit 25 is connected to the oxygen-enriched air generating means 8 at the upstream side of the oxygen permselective membrane 15.

Fig. 4 is an enlarged cross-sectional view of the burner 2 in Fig. 3, showing its structure. The burner 2 consists of a wind box 26 covering the opening 17 of the main body of furnace 1a and the fuel spraying cylinder 20 thrust into it. This fuel spraying cylinder 20 is a two-fluid sprayer hitherto well known; and it can be either of the so-called "inside mixing type" or of the "outside mixing type". To the fuel spraying cylinder 20 are connected the fuel supply pipe 4 and the pipe conduit 7. Further, to the wind box 26 is connected the pipe conduit 9.

In the burner 2, liquid fuel is jetted from the fuel spraying cylinder 20 as it is atomized by nitrogen-enriched air. It is a common knowledge that, when steam or gaseous fuel is utilized as an atomizing medium of liquid fuel, the amount of NO<sub>x</sub> generated is reduced; and it is obvious that, even if liquid fuel is atomized by utilization of nitrogen-enriched air, as the primary air, like in this case, there is also a reduction in the amount of NO<sub>x</sub> generated. Moreover, since oxygen-enriched air is supplied as the secondary air, there occurs no degradation of the combustion efficiency of the burner 2, but a satisfactory combustion can be maintained.

As, furthermore, the oxygen-enriched air is preheated, the combustion efficiency is further enhanced.

Fig. 5 is an enlarged cross-sectional view of the burner 2 in still another example of the embodiment of the present invention. In the main body 31 of this burner 2, there are formed, by a spray nozzle 32 and an air nozzle 33, three channels, viz., the first channel 34, the second channel 35 and the third channel 36, concentrically disposed in the order mentioned from inside outward in the radial direction. In front of the main body 31, there are provided burner tile 37 (at left in the figure). Into the first channel 34, the innermost in the radial direction, is supplied liquid fuel. Into the third channel 36, radially the outermost, is supplied air by means of a force fan 38. Into the second channel 35 is supplied, through a pipe conduit 42, an air of which the oxygen concentration has been made higher by the oxygen permselective membrane 15, by means of a vacuum pump 40 and a blower 41.

The vacuum pump 40 sucks air from the oxygen permselective membrane 15 at, for instance, -600mmHg and supplies the blower 41 with oxygen-enriched air at about the atmospheric pressure. The oxygen permselective membrane 15 has such a property that, as soon as there begins the transmission of air through it, there immediately takes place polarization of a hard-to-permeate gas on the surface of

membrane, hampering separation of oxygen from air. To prevent such, it is essential that new air be constantly supplied to the surface of membrane. The use of the vacuum pump 40 which induces air to permeate the oxygen permselective membrane 15 ensures the flow of necessary amount of air through the membrane, offering a great advantage in respect of savings in energy. For the purpose of prevention of occurrence of pulsation in the flow of gas from the vacuum pump 40, there is provided the blower 41; and this ensures the supply of oxygen-enriched air through the pipe conduit 42 at a certain fixed rate of flow. The flow rate of oxygen-enriched air can be controlled by a flow-rate control valve 48 provided midway in a bypass 47 of the pipe conduit 42 connecting the vacuum pump 40 with the oxygen-enriched air generating means 8 and the burner 2.

Oxygen-enriched air passes through the second channel 35; and, at the end of the main body 31 of the burner 2, it atomizes liquid fuel from the first channel 34. Liquid fuel thus atomized mixes with oxygen-enriched air; hence a combustion at very high temperature can be realized.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by

the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

CLAIMS

1. A combustion apparatus for burning liquid fuels, having a burner 2 for atomizing and burning the liquid fuels, characterized in that there is provided supply means for supplying oxygen-enriched air obtained by passing normal air through an oxygen permselective membrane 15 to the burner 2 as air for combustion.

2. A combustion apparatus for burning liquid fuels as claimed in claim 1, characterized in that the liquid fuels are atomized by gaseous fuels.

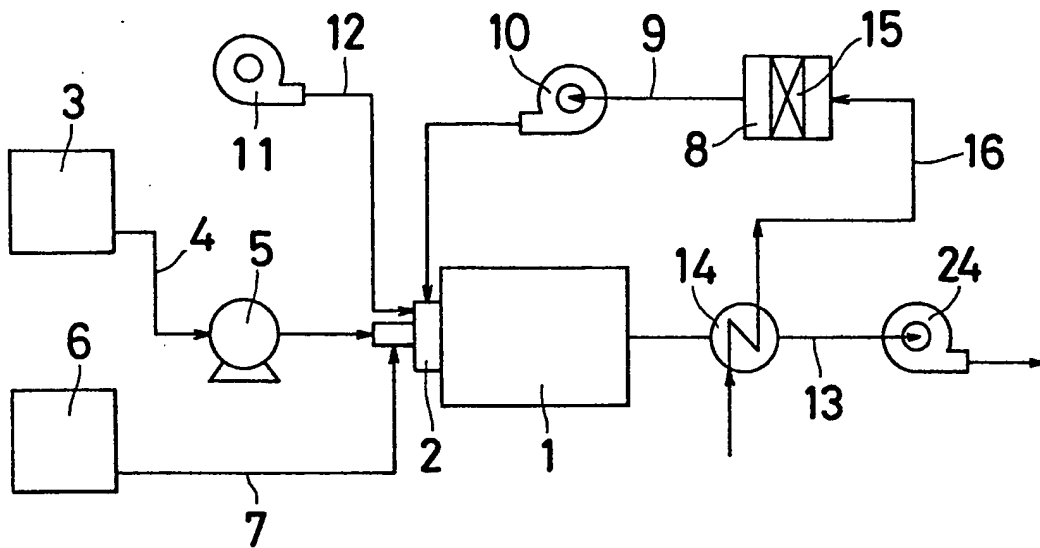
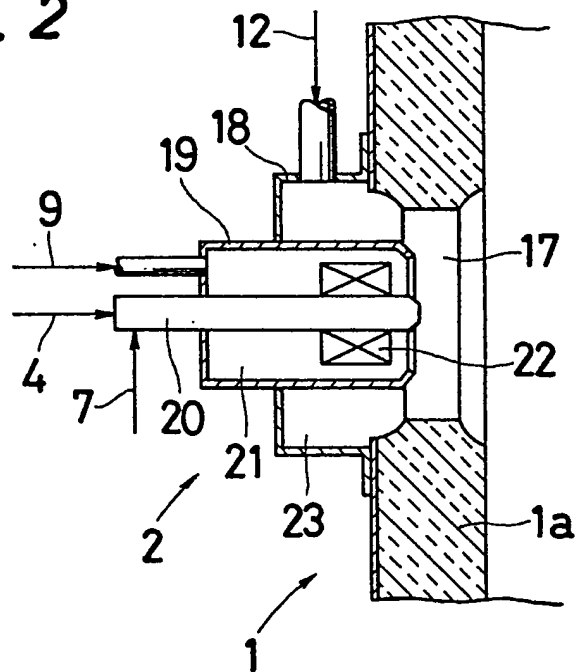
3. A combustion apparatus for burning liquid fuels as claimed in claim 1, characterized in that the liquid fuels are atomized with nitrogen-enriched air obtained by passing normal air through an oxygen permselective membrane 15.

4. A combustion apparatus for burning liquid fuels as claimed in claim 1,<sup>2 or 3,</sup> characterized in that the oxygen-enriched air is preheated with exhaust gas from the burner 2 by heat exchange.

5. A combustion apparatus for burning liquid

fuels as claimed in claim 1,<sup>2 or 3,</sup> characterized in that the air supplied for the oxygen permselective membrane 15 is pre-heated with exhaust gas from the burner 2 by heat exchange.

6. A combustion apparatus for burning liquid fuels as claimed in/<sup>any preceding</sup>claim, characterized in that there are provided first channel 34, second channel 35 and third channel 36 concentrically disposed in the order from inside outward in the radial direction, the first channel 34 is for use to be supplied with liquid fuels, the second channel 35 is for use to be supplied with oxygen-enriched air formed by means of oxygen-enriched air generating means, and the third channel 36 is for use to be supplied with normal air.

*Fig. 1**Fig. 2*



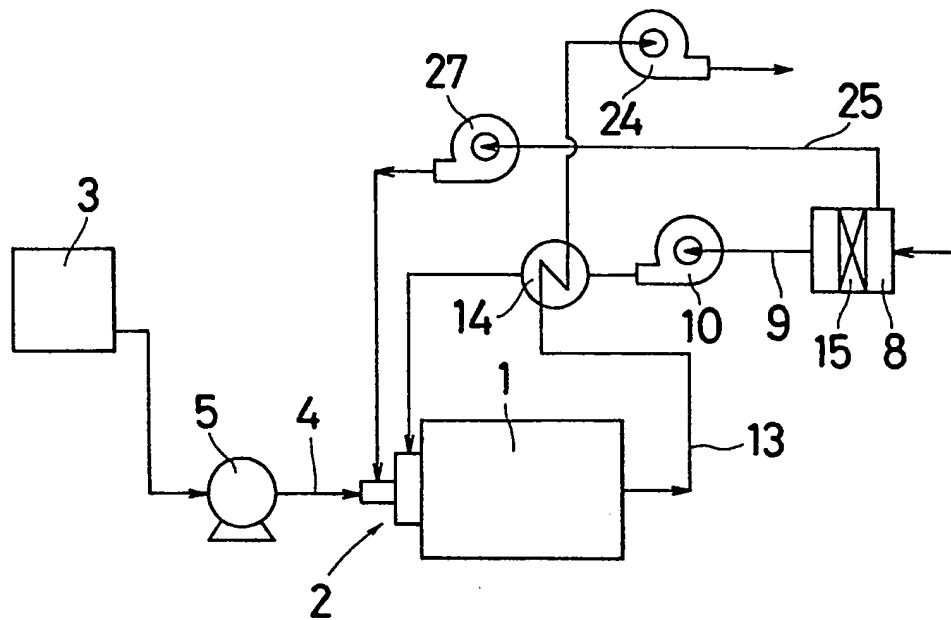
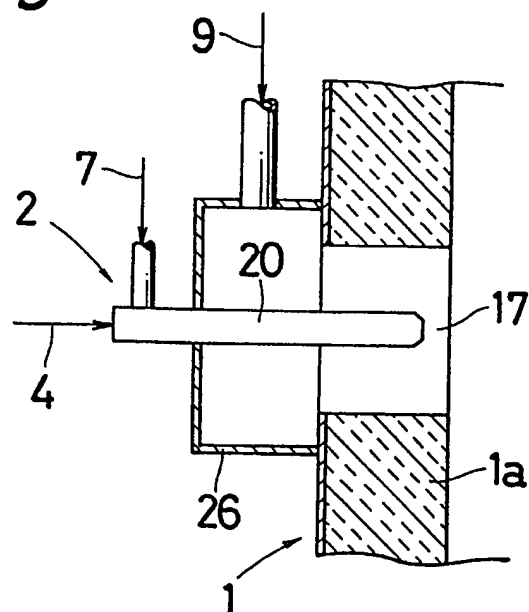
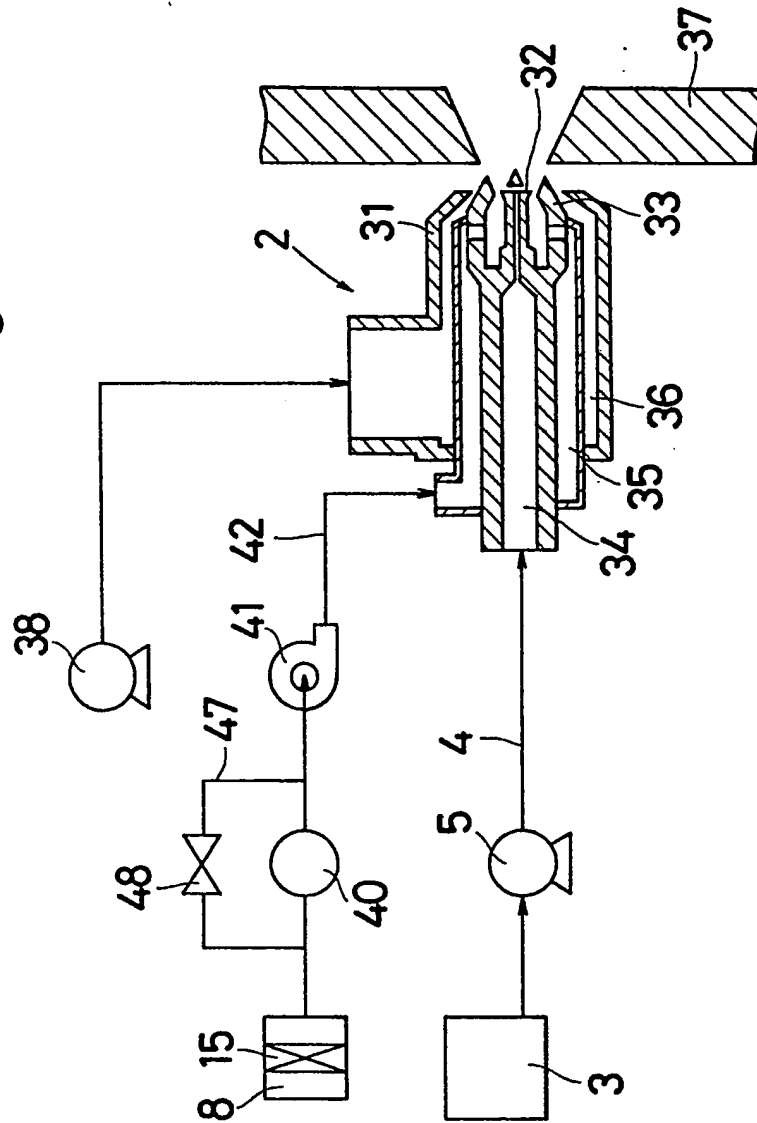
*Fig. 3**Fig. 4*

Fig. 5



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**US-CL-CURRENT:** 431/159

**ABSTRACT:**

CHG DATE=19990617 STATUS=O> A combustion apparatus for burning liquid fuels, having a burner 2 for atomizing and burning the liquid fuels. The combustion apparatus comprises supply means for supplying oxygen-enriched air obtained by passing normal air through an oxygen permselective membrane 15 to the burner 2 as air for combustion.

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**Abstract Text - FPAR (1):**

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